Exhibit A

PRINCIPLES OF POLYMER SYSTEMS

Second Edition

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3 Physical States and

3-1 Physical States
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TABLE 10-1
Specific Gravity of Polymers

Chemical composition of polymer	Typical specific gravity of pure polymer near room temperature
Aliphatic hydrocarbons (polyethylene, polyisoprene)	0.8–1.0
Aromatic hydrocarbons and silicones (polystyrene)	1.0–1.1
Oxygen and nitrogen-containing polymers (cellulosics, polyesters, polyamides)	1.1–1.4
Chlorinated polymers	1.2–1.8
Fluorinated polymers	1.8–2.2

10-5 THERMAL PROPERTIES

Many polymers have a coefficient of linear thermal expansion α_e in the range of 2 to 20×10^{-5} cm/cm·°C, compared to steel at about 1×10^{-5}. This complicates the design of molds for precision parts and the design of metal inserts in polymer parts. Of course, α_e varies with the state of the polymer, as indicated earlier in comments on the variations of specific volume at T_g and T_m (Sec. 3-4). Replacement of polymer by less expansile fillers lowers the overall expansion.

Thermal conductivity k_c of polymers is uniformly low. Values of $k_c = 0.05$ to 0.20 Btu/ft·h·°F are common.

$$\frac{242\ \text{Btu}}{\text{ft}\cdot\text{h}\cdot{}^\circ\text{F}} = \frac{1\ \text{cal}}{\text{cm}\cdot\text{s}\cdot{}^\circ\text{C}} = \frac{419\ \text{watt}}{\text{m}\cdot{}^\circ\text{C}} .$$

Conductivity is not easily increased. A high concentration of a metal in powder or fiber form can raise it perhaps tenfold. In Table 10-3 the thermal conductivity of the base resins can be increased by aluminum or copper metal. These also increase electrical conductivity. If low electrical conductivity (for example, 10^{-16} S) is desired, the mixture of aluminas can give a high thermal conductivity. Foaming with air or some other gas is used to decrease thermal conductivity. A foamed polystyrene with a

TABLE 10-2
Specific Gravity of Filled Polymers

Parts by weight	Polymer	Specific gravity	Parts by weight	Filler	Specific gravity	Final specific gravity
100	Natural rubber	0.93	50	Carbon black	1.8	1.1
100	Natural rubber	0.93	100	Calcined clay	2.6	1.4
100	Epoxy resin	1.2	200	Glass fibers	2.5	1.8
100	Phenolic resin	1.3	100	Wood flour	0.9	1.1
100	Polyurethane	1.2	900 (pts by vol)	Nitrogen		0.12

TABLE 10-3
Thermal Conductivity of Various F

Filler	Volume p fille comp
Aluminum, 30 mesh	6
Sand, coarse grain	6
Mica, 325 mesh	2
Alumina, tabular	5
Alumina, 325 mesh	5
Copper powder	6
Silica, 325 mesh	3
Mixture of:	
Alumina, tabular (20 to 30 mesh)	4
Alumina, 325 mesh	2

density of 2.5 lb/ft³ and a $k_c = 0.$
of applications from picnic baskets
average temperature is shown in Fig

A *specific heat* of 0.4 ± 0.1 ca
generally have the average specific
that varies with the physical state of

The yielding of a polymer u
at a *deflection temperature* that is
distortion temperature is still used i

Flammability is a function of
foamed material or a thin film pre
heavy solid section. Chemical comp
molecular-weight compounds. In ger

Most flammable: Nitrated polym
Oxygen-contai
Hydrocarbon p
Polyamides
Least flammable: Halogenated po

Certain plasticizers (phosphate est
trioxide combined with chlorinate
On the other hand, nitroglycerine
objective is to maintain the flammab

10-6 ELECTRICAL PROPER

Resistance is a familiar electrical pro
ohms of a material 1 cm thick, t, a
R of any other configuration is given